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Air Management

Subject **Page**

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Air Management

Model: All

Production: All

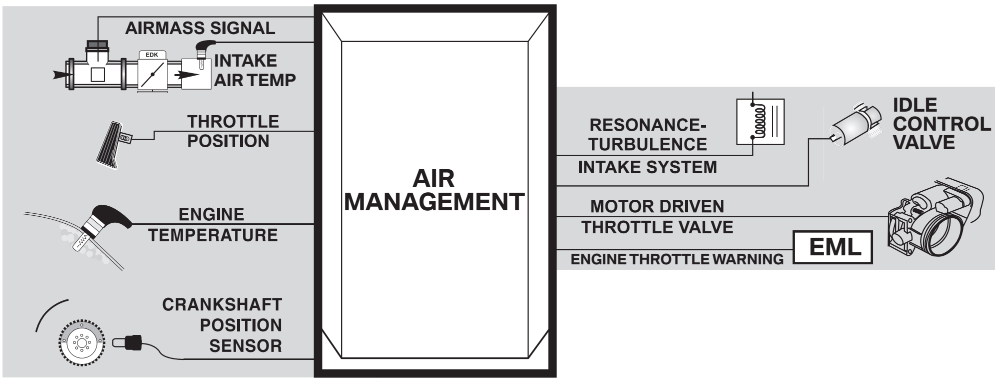
OBJECTIVES

After completion of this module you will be able to:

- Understand how different intake manifolds and air intake systems function
- Understand how the Air System influences Engine Management
- Be able to test the Mass Air Flow system
- Be able to test the throttle assembly and the inputs that affect the throttle
- Understand EDK and Idle Air Actuator operation

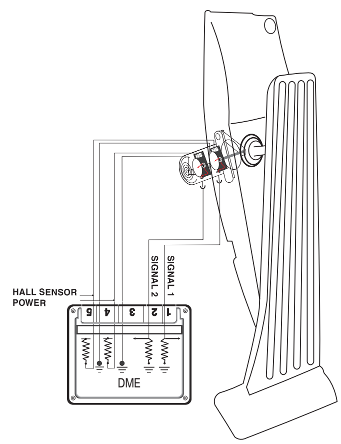
Air Management

Example of IPO for an Air Management System



One of the main purposes of the ECM is Air Management which includes the actuation of several components. In the following pages you will find a generic explanation on how this system works. For more detailed information please access BMW Training Reference Manuals found online.

Air flow into the engine is regulated by the Throttle Valve and/or the Idle Air Actuator. Both of these air "passages" are necessary for smooth engine operation from idle to full load. The Throttle Valve and the Idle Air Actuator are **electrically controlled**. All of the ECM monitoring, processing and output functions are a result of regulated air flow.



Accelerator Pedal Position (Pedalwertgeber - PWG)

The Accelerator Pedal Position is monitored by the ECM for pedal angle position and rate of movement. As the accelerator is moved, it provides two variable voltage signals to the ECM that represents accelerator pedal position and rate of movement.

Dual Hall Sensors are integral in the accelerator pedal module. The ECM compares the two values for **plausibility**. The module contains internal springs to return the accelerator pedal to the rest position.

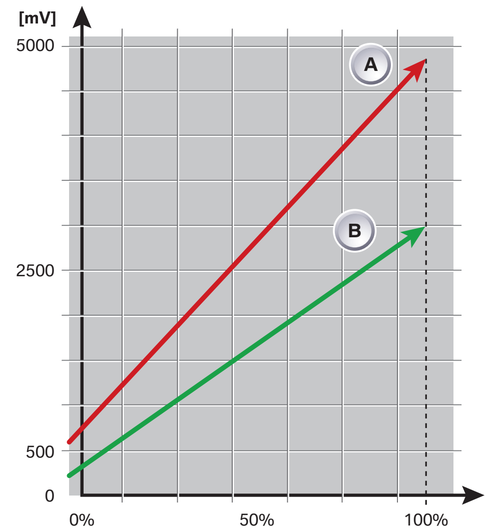
The ECM will increase the volume of fuel injected into the engine, advance the ignition timing and open the Throttle Valve and/or Idle Air Actuator.

The "full throttle" position indicates maximum acceleration to the ECM, and in addition to the functions just mentioned, this will have an effect on the air conditioning compressor.

As the accelerator pedal is released (integral springs), a decrease in voltage signals the ECM to activate fuel shut off if the RPM is above idle speed (coasting). When the Throttle Valve is completely closed, the Idle Air Actuator is opened to maintain engine idle speed.

The ECM monitors the engine idle speed in addition to the accelerator pedal position and throttle position voltage. If the voltage values have changed (mechanical wear of throttle plate or linkage), the ECM will adjust the Idle Air Actuator to maintain the correct idle speed.

The Potentiometers/Hall sensors are non-adjustable because the ECM "learns" the throttle angle voltage at idle speed. If the throttle housing/accelerator pedal module is replaced, the adaptations must be cleared and adaptation procedure must be performed using ISTA. If this is not performed, the vehicle will not start, or run in "fail-safe" mode.



If this input is defective, a fault code will be stored and the "Malfunction Indicator and/or EML" Light will be illuminated. Limited engine operation will be possible.

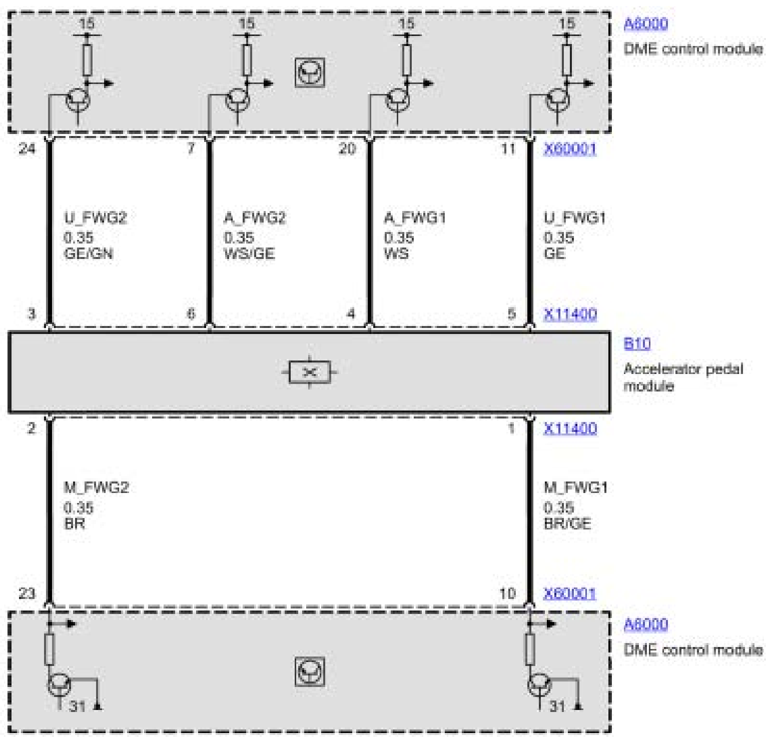
The ECM provides voltage (5V) and ground for the Hall sensors. As the accelerator pedal is moved from rest to full throttle, the sensors produce a variable voltage signal.

- Hall sensor 1(request)
- Hall sensor 2 (plausibility)

If the signals are not plausible, the ECM will use the lower of the two signals as the requested input. The throttle response will be slower and the maximum throttle response will be reduced.

The pedal position sensor is **monitored** by checking **each individual sensor circuit** and comparing the two pedal values. Monitoring is active as soon as the sensors receive voltage (KL15). The ECM decides what operating mode the pedal position sensor is to assume.

- Pedal position sensor fully operable.
- Failure of one pedal position sensor (maximum engine speed is limited).
- Failure of both pedal position sensors (engine speed limited to 1500 rpm).



Throttle Valve (EDK)

The throttle valve plate is electronically operated to regulate intake air flow by the ECM. The main characteristics are:

- Precision throttle operation,
- OBD compliant for fault monitoring,
- DSC and Cruise Control.

This integrated electronic throttle reduces extra control modules, wiring, and sensors. Adjusting electronic throttles is not permitted, the throttle assembly must be replaced as a unit. The adaptation values must be cleared and adaptation procedure must be performed using ISTA.

The throttle assembly for the system is referred to as the EDK:

- EDK does not contain a PWG, It is remotely mounted (integrated in the accelerator pedal assembly).
- The accelerator pedal is not mechanically “linked” to the EDK.

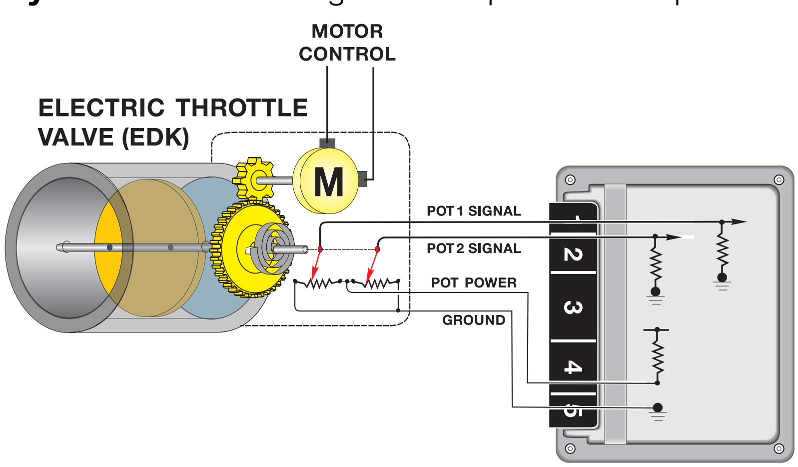
Throttle Motor and Feedback Position

The ECM powers the EDK motor using pulse width modulation (PWM) for opening and closing the throttle plate. The throttle plate is also closed by an integrated return spring.

Two integrated potentiometers provide voltage feedback signals to the ECM as the throttle plate is opened and closed.

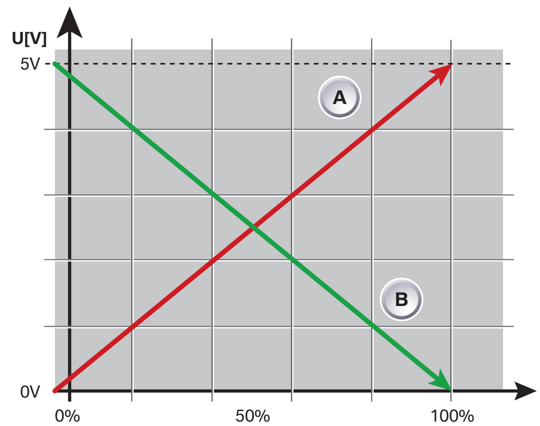
- **Feedback signal 1** provides a signal from approx. 0.5V (closed) to approx. 4.5 V (Full Throttle)
- **Feedback signal 2** provides a signal from approx. 4.5V (closed) to approx. 0.5V (Full Throttle)

Potentiometer 1 is the **primary feedback** signal of throttle plate position and signal is the **plausibility cross check** through the complete throttle plate movement.



Total Intake Air Flow Control is performed by the ECM simultaneously operating the EDK throttle control and the Idle Air Actuator.

The ECM detects the driver's request from the potentiometers/Hall Sensors monitoring the accelerator pedal position. This value is added to the Idle Air control value and the total is what the ECM uses for EDK activation. The ECM then controls the Idle Air Actuator to satisfy the idle air "fill". In addition, the EDK will also be activated = pre-control idle air charge. Both of these functions are utilized to maintain idle RPM.



The EDK is electrically held at the idle speed position, and all of the intake air is drawn through the Idle Air Actuator. Without a load on the engine (<15%), the EDK will not open until the extreme upper RPM range. If the engine is under load (>15%), the Idle Air Actuator is open and the EDK will also open.

Vehicles equipped with VALVETRONIC, e.g. N52, N55, will only use the EDK in certain operating conditions.

All variants of the **NG6 engines** receive the new EGAS 08 throttle by Siemens/VDO. The new throttle uses a plastic throttle valve and magneto-resistive feedback to the ECM.

The previous system used a potentiometer, whereas the new
throttle uses a “contactless” system featuring magneto-resistive technology which is familiar from the eccentric shaft sensor on Valvetronic systems.

The magneto-resistive sensors are integrated into the housing cover. The sensors are also non-wearing.

For plausibility, the one sensor outputs the analog signal in the range from **0.3 to 4.6 V** and the other sensor inverts it again from **4.6 to 0.3 V.**

Consequently, the contact force is 10 times greater than that of a conventional plug connector

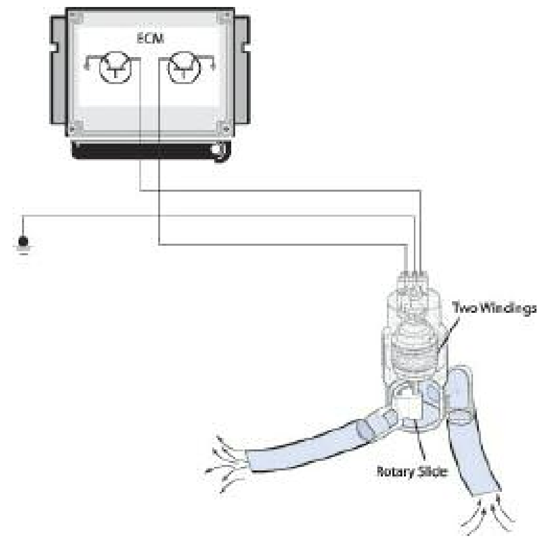
It is possible to twist the connector before plugging it in.
This can cause damage to the harness and connector.

Failsafe Operation - EDK

When a fault is detected in the system:

- The EDK provides two separate signals from two integrated potentiometers (Pot 1 and Pot 2) representing the exact position of the throttle plate.
- EDK Pot 1 provides the primary throttle plate position feedback. As a redundant safety feature, Pot 2 is continuously cross checked with Pot 1 for signal plausibility.
- If plausibility errors are detected between Pot 1 and Pot 2, the ECM will calculate the inducted engine air mass (from HFM signal) and only utilize the potentiometer signal that closely matches the detected intake air mass.
  - The ECM uses the air mass signaling as a “virtual potentiometer” (Pot 3) for a comparative source to provide failsafe operation.
  - If the ECM cannot calculate a plausible conclusion from the monitored Pots (1 or 2 and virtual 3) the EDK motor is switched off and fuel injection cut out is activated (Failsafe operation is not possible).
- The EDK is continuously monitored during all phases of engine operation. It is also briefly activated/adapted when KL_15 is initially switched on as a “preflight check” to verify it’s mechanical integrity (no binding, appropriate return spring tension, etc). This is accomplished by monitoring both the motor control amperage and the reaction speed of the EDK feedback potentiometers. If faults are detected the EDK motor is switched off and the fuel injection cut off is activated (failsafe operation is not possible). The engine does however continue to run extremely rough at idle speed.
- When in emergency operation, the engine speed is always limited to 1300 RPM by fuel injector cutout, and activation of the “EML” light to alert the driver of a fault.
- When a replacement EDK is installed, the ECM adapts to the new component (required amperage draw for motor control, feedback pot tolerance difference, etc). This occurs immediately after the next cycle of KL_15 for approximately 30 seconds. During this period of adaptation, the maximum opening of the throttle plate is 25%.

Idle Air Actuator



This valve regulates air by-passing the throttle valve to control the engine idle/low speed.

The valve is supplied with battery voltage from the ECM Relay. The Idle Air Actuator is a two-coil rotary actuator. The ECM is equipped with two final stage transistors which will alternate positioning of the actuator.

The final stages are "pulsed" simultaneously by the ECM which provides ground paths for the actuator. The duty cycle of each circuit is varied to achieve the required idle RPM.

If this component/circuits are defective, a fault code will be set and the “Malfunction Indicator Light” will be illuminated when the OBD II criteria is achieved.

The Idle Air Actuator is controlled by the ECM modulating the ground signals (PWM at 100 Hz) to the valve. By varying the duty cycle applied to the windings, the valve can be progressively opened, or held steady to maintain the idle speed.

The ECM controls the Idle Air Actuator to supply the necessary air to maintain idle speed. When acceleration is requested and the engine load is low (<15%), the actuator will also supply the required air.

The basic functions of the idle speed control are:

- Control the initial air quantity (air temp <0° C, EDK is simultaneously opened).
- Variable preset idle based on load and inputs.
- Monitor RPM range intake for each preset position.
- Vacuum Limitation
- Smooth out the transition from acceleration to deceleration.

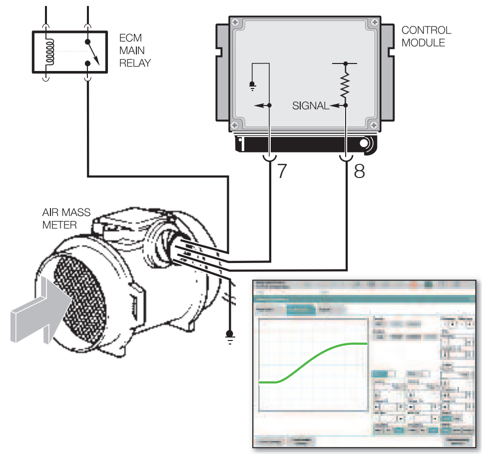
Under certain engine operating parameters, the EDK throttle control and the Idle Air Actuator are operated simultaneously. This includes all idling conditions and the transition from off idle. As the request for load increases, the idle valve will remain open and the EDK will supply any additional air volume required to meet the demand.

Failsafe Operation - Idle Air Actuator

If a fault is detected with the Idle Air Actuator, the ECM will initiate failsafe measures depending on the effect of the fault (increased air flow or decreased air flow). If there is a fault in the Idle Air Actuator/circuit, the EDK will compensate to maintain idle speed. The “Malfunction Indicator and/or EML” Light will be illuminated to inform the driver of a fault.

If the fault causes increased air flow (actuator failed open), VANOS and Knock Control are deactivated which noticeably reduces engine performance.

Hot-Film Air Mass Meter (HFM)



The air volume input signal is produced electronically by the HFM which uses a heated metal film (180º C above intake air temperature) in the air flow stream.

The ECM Relay provides the operating voltage. As air flows through the HFM, the film is cooled changing the resistance which affects current flow through the circuit. The sensor produces a 1-5 volt varying signal. Based on this change the ECM monitors and regulates the amount of injected fuel.

The Hot-Film Air Mass Meter (HFM) varies voltage monitored by the ECM representing the measured amount of intake air volume. This input is used by the ECM to determine the amount of fuel to be injected.

The heated surface of the hot-film in the intake air stream is regulated by the ECM to a constant temperature of 180º C above intake air temperature. The incoming air cools the film and the ECM monitors the changing resistance which affects current flow through the circuit. The hot-film does not require a “clean burn”, it is self cleaning due to the high operating temperature for normal operation.

If this input is defective, a fault code will be set and the “Malfunction Indicator Light” will illuminate when the OBD II criteria is achieved. The ECM will maintain engine operation based on the Throttle Position Sensors and Crankshaft Position/Engine Speed Sensor.

The HFM is non-adjustable.

HFM on NG6 Engines
The HFM on all new NG6 engines has been upgraded to a digital HFM. The output of the sensor is a digital signal in which the duty cycle responds to changes in air mass.

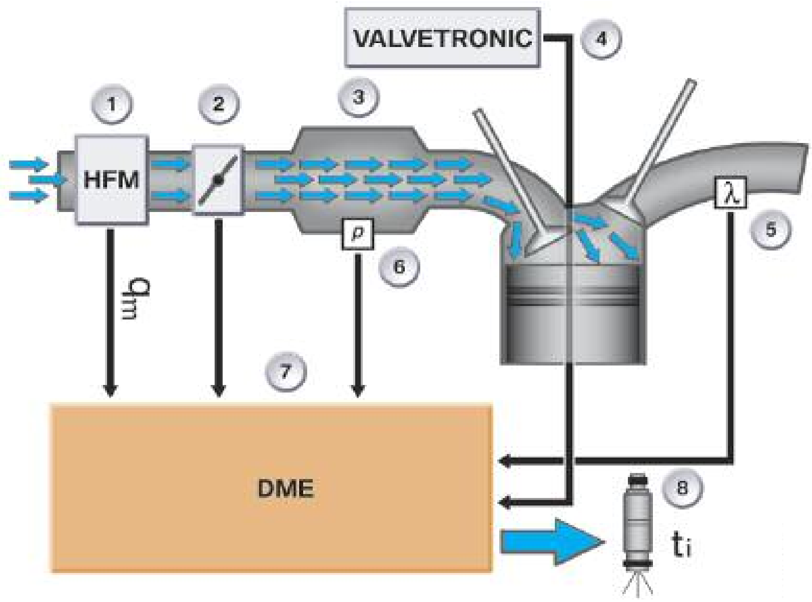
The Siemens SIMAF GT2 Hot-Film air Mass meter is used in several BMW engines. This sensor is equipped with planar metal resistors on glass. Based on the tried and tested sensor technology used in the SIMAF GT1 for more than 15 years, the SIMAF GT2 represents a further-development and optimization with higher vibration resistance, improved accuracy (at all operating temperatures), and lower sensitivity to air pulsations and water.

The output of the sensor is converted to a digital signal. This eliminates the need for signal conversion in the ECM. The signal corresponds proportionally to changes in air mass.

Hot-film air mass meter

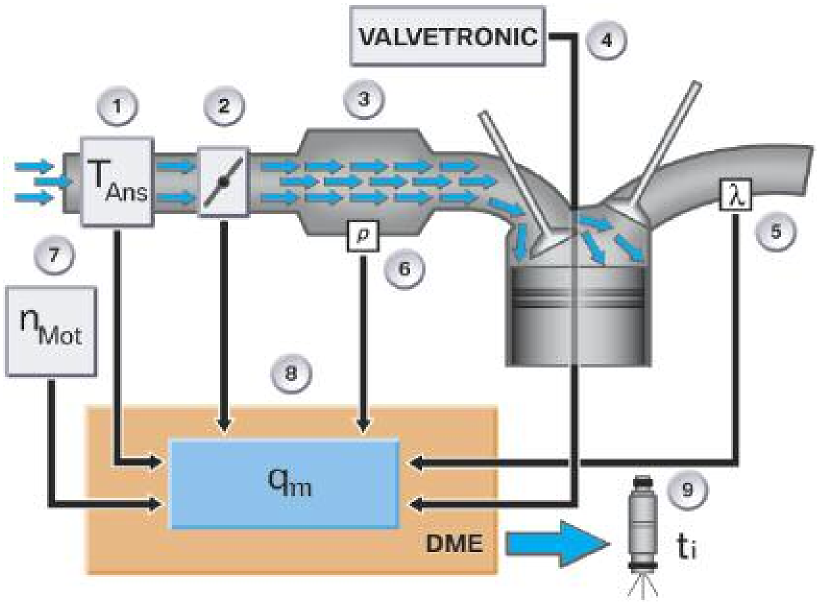
The N54 engine uses a virtual HFM. The signal is "calculated" in the ECM from various parameters such as engine speed, intake air temperature, throttle position etc.

Air Measurement with HFM



Index	Explanation	Index	Explanation
1	Measurement of intake air temperature and air mass	5	Residual O2 content in exhaust gas
2	Throttle valve position	6	Intake manifold vacuum
3	Intake manifold	7	Engine speed
4	Intake valve lift (from VVT)	8	Injection Timing

"Virtual" Air Measurement without HFM



Index	Explanation	Index	Explanation
1	Intake air temperature	6	Intake manifold vacuum
2	Throttle valve position	7	Engine speed
3	Intake manifold	8	ECM (DME) with characteristic map for air mass calculation
4	Intake valve lift (VVT if equipped)	9	Injection Timing
5	Residual O2 content in exhaust (O2 sensor)		

The HFM is non-adjustable and tampering is not permitted. A faulty Hot-Film Air Mass Sensor can produce the following complaints:

- **Difficult To Restart When Engine Is Hot.**
- **Engine Starts Then Stalls.**
- **"Malfunction Indicator Light" Illuminated.**
- **Engine Starts and Runs Only With Accelerator Pedal Depressed.**

Air Temperature Signal

The HFM contains an integral air temperature sensor. This is a Negative Temperature Coefficient (NTC) type sensor. This signal is required by the ECM to correct the air volume input for changes in the intake air temperature (air density) affecting the amount of fuel injected, ignition timing and Secondary Air Injection activation.

The ECM provides the power supply to the sensor which decreases in resistance as the temperature rises and vice versa. The ECM monitors an applied voltage to the sensor that will vary as air temperature changes the resistance value.

If this input is defective, a fault code will be set and the "Malfunction Indicator Light" will be illuminated when the OBD II criteria is achieved. The ECM will operate the engine using the Engine Coolant Sensor input as a back up.

The Air Temperature signal allows the ECM to make a calculation of intake air temperature. The varying voltage input from the NTC sensor indicates the larger proportion of oxygen found in cold air, as compared to less oxygen found in warmer air. The ECM will adjust the amount of injected fuel because the quality of combustion depends on oxygen sensing ratio.

The ignition timing is also affected by air temperature. If the intake air is hot the ECM retards the base ignition timing to reduce the risk of detonation. If the intake air is cooler, the base ignition timing will be advanced. The ECM uses this input as a determining factor for Secondary Air Injection activation.

If this input is defective, a fault code will be set and the "Malfunction Indicator Light" will illuminate when the OBD II criteria is achieved. The ECM will maintain engine operation based on the HFM and Engine Coolant Temperature sensor.

Variable Intake Manifold (DISA)

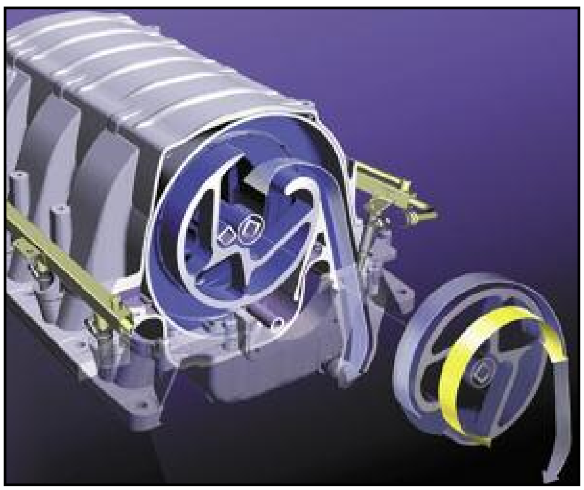
Fully Variable DISA

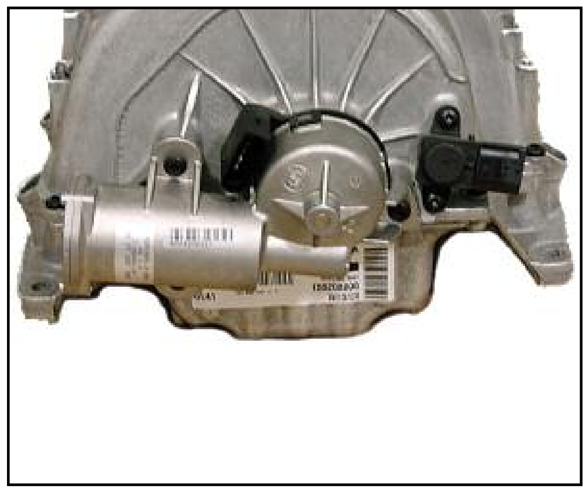
In the **N62** engine, the infinitely variable differential intake air system **(DISA)** intake manifold is operated by turning the rotor in the intake manifold.

Adjustments to the intake manifold are carried out by the ECM controlling a drive unit. The drive unit is mounted on the rear of the intake manifold.

The drive unit consists of a **12V DC** electric motor with worm gears and an integral potentiometer for the intake manifold position feedback.

The drive unit is equipped with a 5-pin connector.





If the drive unit fails, the system remains in its current position. The driver may notice a loss in power.

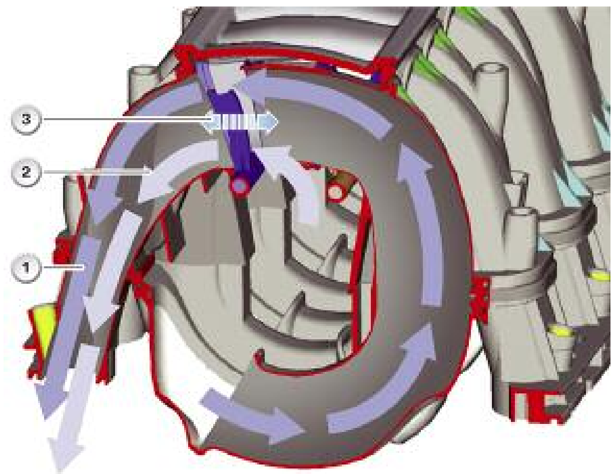
Two Stage DISA

The previous fully variable intake system is no longer used in the **N62TU** engine. A new two-stage intake system (DISA) is used instead. The previous intake manifold was made from magnesium; the new intake is manufactured from glass fiber reinforced plastic.

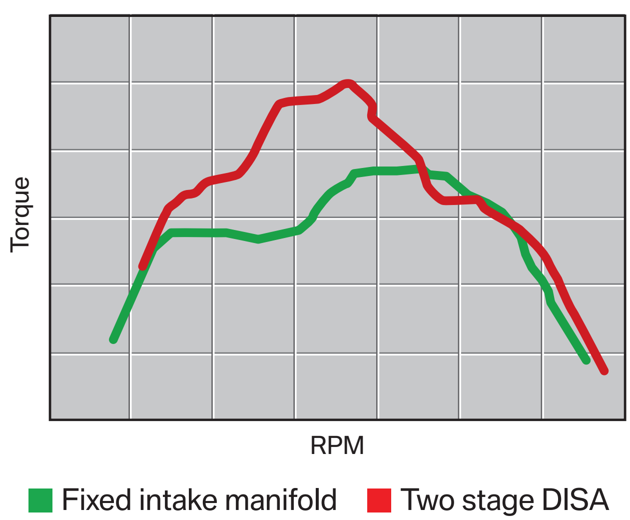
There are two servomotors which provide a 2-stage (long/short) function of the intake manifold runners. Due to the increased displacement and engine power, the fully variable intake system is no longer required.

The **12V** servomotors are actuated by the ECM via a PWM signal. While the sliding sleeves are open (power setting), the servomotors are actuated with a **5 % PWM** signal in order to hold the sleeves in their open position.

Index	Explanation
1	Servomotor, cylinder bank 1
2	Differential Pressure Sensor
3	Servomotor, cylinder bank 2
4	Bores for fuel injectors



Index	Explanation
1	Long Intake Passage
2	Short Intake Passage
3	Directional movement of sliding sleeves



Variable Intake Manifold (DISA)

The intake manifold on the **N52** uses a three stage differential intake air system **(DISA)**. The air flow through the intake manifold is controlled and re-directed by two DISA actuator motors.

Each actuator motor is operated by an electric motor controlled by the Engine Control Module (ECM) via a PWM signal. The **PWM** signal is at a frequency of 200 Hz. The ECM varies the duty cycle to control the position of the DISA flap. The actuator consists of a flap and motor drive. **There are only two positions possible - closed or opened.** When activated, the motor moves the flap to each end position. Both actuators are switched to the closed position at idle.

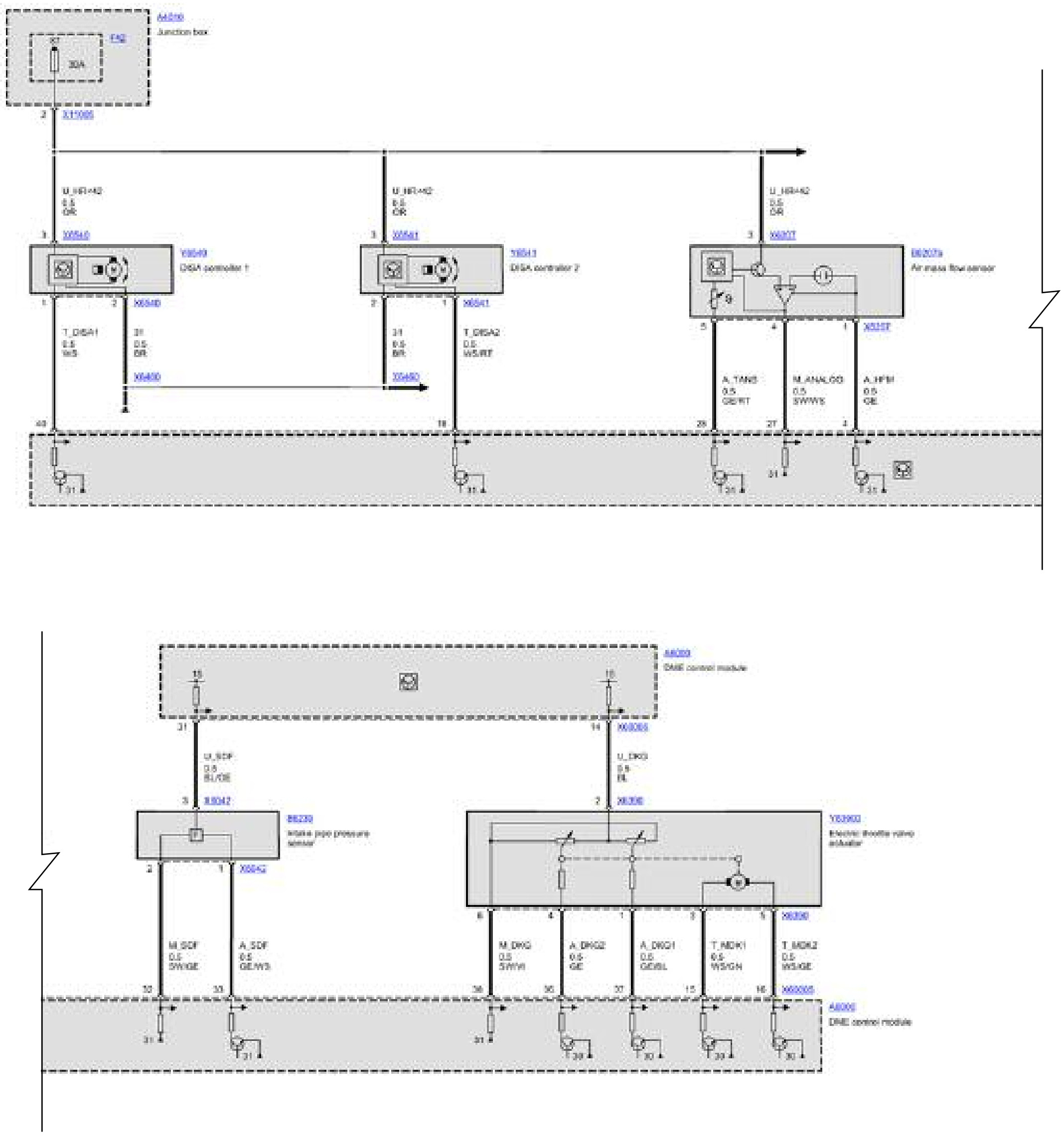
The DISA motors are similar in design and operation, but they are not interchangeable. Each actuator assembly has it’s own individual part number.

DISA Actuators

Together with the drive, the DISA valve (flap) forms one unit. The DISA valve is driven by an electric motor and a gear mechanism.

The electronic control is integrated in the DISA actuator. The DISA actuator is driven by a pulse width-modulated signal from the DME.

There are only two possible positions: The valves (flaps) can either be closed or opened, i.e. when activated, the motor moves the valve to the respective end position.

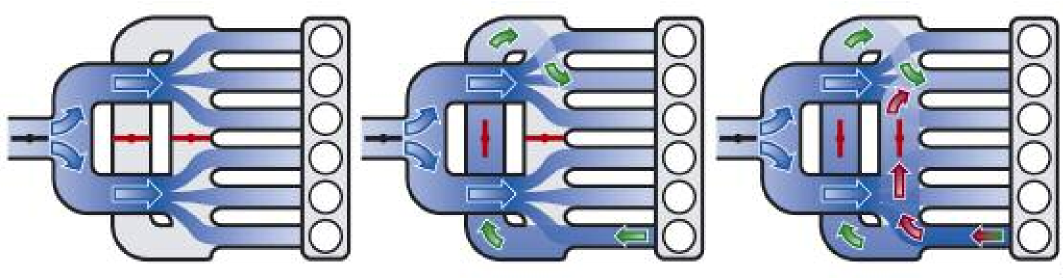


DISA Operation

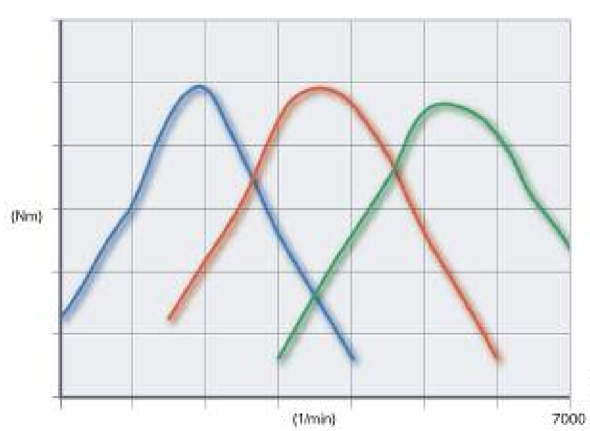
1st stage - idling/lower engine speed range
At idle speed and in the lower engine speed range, actuators 1 and 2 are closed. The intake air flows past the throttle valve into the resonance pipe. In the resonance pipe, the intake air mass splits. The air is fed via the collector pipe and resonating pipes into the individual cylinders. In this way, three cylinders are provided with a comparably high air mass.

2nd stage - medium engine speed range
In the medium engine speed range, DISA actuator motor 2 is opened. In this case, it is assumed that the inlet valves of the first cylinder are just closing. The gas motion creates a pressure peak at the closing inlet valves. This pressure peak is passed on via the resonating and collector pipes to the in next cylinder in the firing order. This improves the fresh gas filling of the next cylinder to be filled.

3rd stage - upper engine speed range
In the upper engine speed range, both DISA actuator motors are opened. In this case, it is assumed that the inlet valves of the first cylinder are just closing. The gas motion creates a pressure peak in front of the closing inlet valves. The intake air mass is now fed via the resonating, overshoot and collector pipes.



1st Stage **2nd Stage** **3rd Stage**



DISA N52KP and N51

As far as the air management system on the N52KP and N51 engines is concerned, the previous intake manifold system on the N52 is carried over. Depending upon application, the engines will use the 3-stage DISA or the single stage (no DISA) intake manifold.

For more information on the DISA system refer to the previous training material in the training course "ST501 - New Engine Technology".

Workshop Hints

Air Management

Unmetered air leaks can be misleading when diagnosing faults causing "Malfunction Indicator Light"/driveability complaints. Use the Smoke Machine to help you find leaks.

Crankcase Ventilation System

A fault in this system can often "mislead" diagnosis. This type of fault can produce:

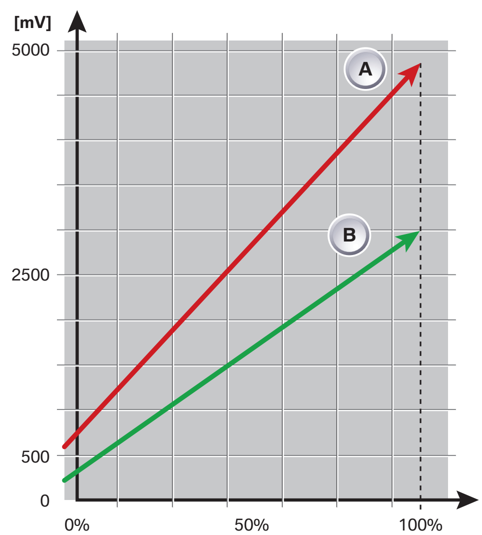
Please refer to the following Service Information Bulletins for details on the Crankcase Ventilation System:

- Mixture/misfire detected codes
- Whistling noise
- Performance/driveability complaints

Accelerator Pedal Position (PWG)

The Throttle Position Sensors can be tested with the following methods:

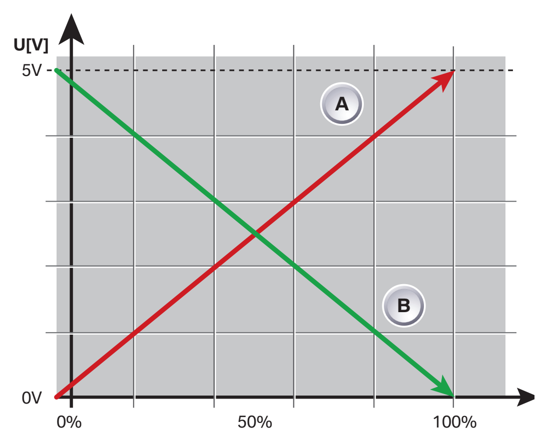
- ISTA Status Page (approx.. 0.5V. to 4.5V)
- IMIB Oscilloscope - Select from the Present measurement which requires taking the measurement with the ECM and the Universal Adapter connected to the circuit as shown on the right).



Throttle Valve (EDK)

Two integrated potentiometers provide voltage feedback signals to the ECM as the throttle plate is opened and closed.

- **Feedback signal 1** provides a signal from approx. 0.5V (closed) to approx. 4.5 V (Full Throttle)
- **Feedback signal 2** provides a signal from approx. 4.5V (closed) to approx. 0.5V (Full Throttle)



Hot-Film Air Mass Meter (HFM)

This component is non-adjustable and tampering is not permitted.
A faulty Hot-Film Air Mass Sensor can produce the following complaints:

- Difficult To Restart When Engine Is Hot.
- Engine Starts then Stalls.
- “Malfunction Indicator Light” Illuminated.
- Engine Starts and Runs Only With Accelerator Pedal Depressed.

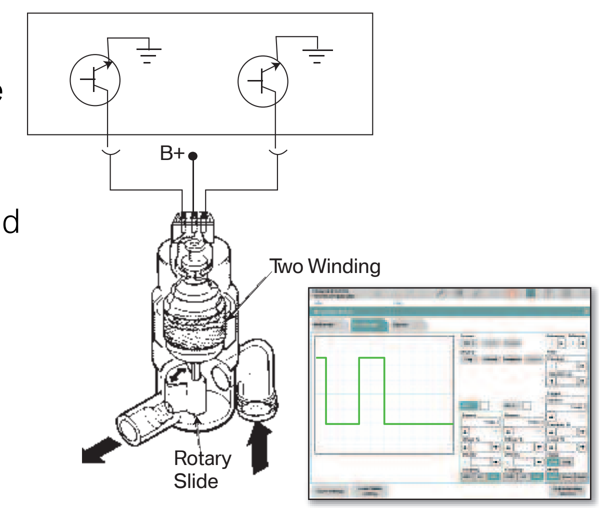
The Hot-Film Air Mass Sensor can be tested with the following methods:

- ISTA Fault Code and Component Testing.
- ISTA Status Page
- IMIB Oscilloscope-which requires taking the measurement with the ECM and the Universal Adapter connected to the circuit (engine running).

Visually inspect the sensor for damaged, missing or blocked screens. The screens affect air flow calibration. Also inspect the sealing rings where the sensor inserts in the air filter housing and intake boot. Ensure the pin connections are tight.

Idle Air Actuator

- The Idle Air Actuator Valve and air circuit (passage ways)should be checked for physical obstructions. Visually inspect the sealing gasket, mounting bracket and air hose clamps.
- The resistance of the valve winding should be checked.
- The ECM output and Idle Speed Control Valve operation can be tested by “Component Activation” on ISTA.
- The Pulse Width Modulation ground outputs from the ECM can be tested using the IMIB Oscilloscope.
- Consult Technical Data for specified idle speed.

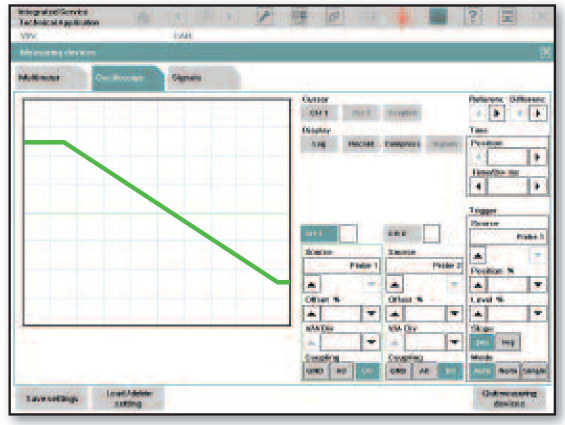


If the valve is blocked or contaminated, an HFM fault code can also be present.

Air Temperature Signal

The HFM contains an integral air temperature sensor. NTC sensors decrease in resistance as the temperature rises and vice versa. The ECM monitors the sensor voltage which varies as temperature changes the resistance value. For example, as temperature rises:

- Resistance through the sensor decreases.
- Voltage drop across the sensor decreases.
- Input signal voltage also decreases (5-0V).



This sensor should be tested using:

- ISTA Diagnostic Query
- IMIB Multimeter (ohms)

NOTES PAGE